

# Abstract

The internal combustion engine is synonymous with the automobile since its invention in late 19<sup>th</sup> century. The internal combustion engine today is far more advanced and efficient compared to its early predecessors. An intense competition exists today amongst the automotive OEMs in various countries and regions for stepping up sales and increasing market share. The pressure on automotive OEMs to reduce fuel consumption and emission is enormous which has led to innovations of many variations in engine and engine-related technologies. However, IC engines are in existence for well more than a century and hence have already evolved to a highly refined state. Changes in IC engine are therefore largely incremental in nature. A deterrent towards development of an engine configuration that is significantly different from its predecessor is the phenomenal cost involved in prototyping. Thus, the only viable alternative in exploring new engine concepts and even optimizing designs currently in operation is through extensive use of CAE.

In light of published work in the field of analysis of IC engines, current research effort is directed towards development of a rational methodology for arriving at a weight-optimized engine design, which simultaneously meets performance of various attributes such as thermal, durability, vehicle dynamics and NVH. This is in contrast to the current methodology adopted in industry, according to which separate teams work on aspects of engine design such as combustion, NVH (Noise, Vibration and Harshness), acoustics, dynamics, heat transfer and durability. Because of the involvement of heterogeneous product development groups, optimization of an engine for weight, which can have a significant impact on its power-to-weight ratio, becomes a slow process beset with manual interventions and compromise solutions. Thus, following the traditional approach, it is quite difficult to claim that an unambiguous weight-optimized design has been achieved. As a departure from the practiced approach, the present research effort

is directed at the deployment of a single multi-physics explicit analysis solver, viz. LS-DYNA - generally known for its contact-impact analysis capabilities, for simultaneously evaluating a given engine design for heat transfer, mechanical and thermal loading, and vibration. It may be mentioned that only combustion analysis is carried out in an uncoupled manner, using proven phenomenological thermodynamic relations, to initially arrive at mechanical and thermal loading/boundary conditions for the coupled thermo-mechanical analysis. The proposed methodology can thus be termed as a semi-integrated technique and its efficacy is established with the case study of designing a single cylinder air-cooled diesel engine from scratch and its optimization.